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VARIABILITY OF COOL CARBON STARS SITUATED NEAR OR IN
INTERMEDIATE-AGE OPEN CLUSTERS

Absolute magnitudes and masses of carbon stars are still very poorly known. Individual parallaxes of carbon stars - members of double or multiple systems or stellar clusters might substantially improve the situation. To get more reliable photometric data for carbon stars situated near or in open clusters, photographic monitoring of these stars have been carried out at Baldone with the Schmidt telescope (80/120/240 cm) of the Radioastrophysical Observatory. The observations have been made in three passbands: R(0.63) - ORWO ZPI plates + Schott RG1 filter, V - A 600 films + ZHS 17 filter, B - ZU2 or ZU21 plates + GG13 filter.

Summary of the photometry of the carbon stars - apparently associated with the intermediate-age (10^9 - 0.4×10^8 years) open clusters are presented in Table I. Of the eleven carbon stars studied eight are named variable stars, the other three have also shown definite light variations. Some additional information for all of the stars follow.

V532 Cas = CCS 3210 = MSB 75 - stable cycle length and light amplitude.

V533 Cas = BC 38 - stable cycle length and light amplitude.

CCS 414 - irregular light variations.

CCS 184 - the interval of observations is too short to determine the type of variability.

FR Per = CCS 183 = neither R(0.63)- nor V- and B-magnitudes showed variations during the observing interval. Only on one plate taken much earlier than others (in the year 1968) the B-magnitude was $0^m.6$ fainter. This result does not contradict the statement that light variations of the star have long waves (1).

- SY Per = CCS 194 = IRC+50115 = AFGL 558. The elements of semi-regular light variations in Table I are given according to the GCVS (7). Our observations confirm them.
- HN Aur = CCS 252 - semiregular light variations, average cycle length about 165 days superimposed on very slow variations with the cycle length of about 1400 days.
- VZ Per = CCS 112 - nonvariable according to (7). Our photometry, however, indicates light variations with a small amplitude. To get a definite conclusion photoelectric observations are necessary.
- DY Per = CCS 107 - in accordance with the GCVS (7) the star had semiregular light variations with a large amplitude and a long period.
- OQ Aur = CCS 339 - irregular or semiregular light variations.
- BC 89 - extremely red star. Light cycles are rather stable, but maximum (or minimum) magnitude is very different for different cycles.

In Table II some characteristics of the observed carbon stars and related open clusters are presented which might give evidence on cluster membership of the stars.

Of the eleven stars six are included in the membership classes 1 and 2. Three of these six stars have large amplitude long-period variations, two - semiregular variation with smaller amplitudes and one - irregular variations. According to Eggen (5), Hartwick and Hesser (6), two further irregular variable carbon stars with small amplitudes are probable members of clusters of similar age with those discussed here. Thus there are eight photometrically studied carbon stars - probable members of intermediate-age open clusters. They are practically equally distributed among the types of variability M, SR, and Lb. It would be of importance to improve the statistics by studying the variability of carbon stars in intermediate-age clusters of southern sky, for example, in NGC 5822 and NGC 3114.

The photometric data obtained from our earlier observations have been published for some of the stars (2,4). Additional data on the photometry of carbon stars near the clusters NGC 7789, NGC 2099, NGC 1528, NGC 1664, and NGC 744 will appear in papers submitted for publication in the serial editions: "Investigations of the Sun and Red Stars" and "Nautchnije Informacii".

Table I

Photometric data and spectra of the observed carbon stars

1	2	3	4	5	6	7	8
Star	Obs.time	V	B-V	V-R	Max.JD24...	P	Sp
V532 Cas	1968-80	9 ^m 9-11 ^m 1	5 ^m 1	1 ^m 5	41238	450 ^d	Ne,C6,3e
V533 Cas	"	12.1-14.3	3.6:	1.4	41250	305	N*
CCS 414	1972-80	12.2-13.0	5.4:	1.7	-	-	N*
CCS 184	1977-80	13.5-14.1	5:	1.9	-	-	-
FR Per	"	10.3	3.0	1.4	-	-	R3;C3,3
SY Per	"	9.1-10.2	5.0	1.6	30525	476	Ne;C4,6
HN Aur	1971-80	11.2-11.7	4.4	1.4	-	165:	N5
VZ Per	1975-78	10.6-10.8	2.2	-	-	-	R4,C4,5J
DY Per	"	10.6-13.2	2.2	-	-	800:	R8,C4,5
OQ Aur	1969-75	14.6-15.3	3.7:	1.6	-	-	-
BC 89	1975-79	11.4-14.4	6:	2.0	42800	470	N*

1. Name of the star in the General Catalogue of Variable Stars (7), or, if the star is not named as a variable, its number in the General Catalogue of Cool Carbon Stars (CCS) (11) or in the lists of carbon stars found at Baldone (BC).
2. Time interval of photometric observations.
3. The range of V-magnitude according to observations made at Baldone.
4. Mean colour index B-V, for fainter stars it refers to the maximum light (symbol :).
5. Mean colour index V-R(0.63).
6. Time of light maximum in Julian days for periodic variable stars.
7. Length of the period or cycle of light variations in days.
8. Spectral class from CCS (11), Larsson-Leander (8) and Yamashita (12,13) or from objective prism spectra taken at Baldone (*).

Table II

Data on the observed carbon stars and related clusters

1	2	3	4	5	6	7	8
Star	Cluster	Age 10 ⁸ y	ρ	ρ/r	V_r	M_v max	Mbsh.
V532 Cas	NGC 7789	9.1	22'	2.3	-46 \pm 3	-2.3	1
V533 Cas	"	"	28	2.9	-	-0.1	2
CCS 414	NGC 2099	1.6	20	1.7	-	+0.6	3
CCS 184	NGC 1528	1.0	29	2.6	-	+3.0	4
FR Per	"	"	37	3.3	-11 \pm 3	-0.3	2
SY Per	"	"	39	3.5	- 1 \pm 8	-1.5	2
HN Aur	NGC 1664	0.89	1	0.2	-	-0.3	2
VZ Per	Tr 2	0.5	17	1.9	-16 \pm 5	+0.8	3
DY Per	"	"	22	2.4	-39 \pm 5	+0.8	4
OQ Aur	NGC 1912	0.43	20	2.3	-	+3.0	4
BC 89	NGC 744	0.39	15	2.2	-	-0.7	2

1. Name of the star as in Table I.
2. Name of the related cluster.
3. Age of the cluster according to Lindoff (9), in 10⁸ years.
4. Angular distance between the star and the cluster centre, in arc minutes.

5. The same distance expressed in angular diameter (according to Trumpler) of the cluster.
6. Radial velocity of the star according to Stanford (10) or Dean (3).
7. Visual magnitude of the carbon star at maximum light, assuming that the star belongs to the cluster. For this estimation the data from col. 3 Table I and published data on the distance of the cluster are used.
8. Membership class, estimated from ρ/r , the place of the star in H-R diagram relative to the observed or expected red giant sequence of the cluster, and the data on radial velocities. Class 1 corresponds to the most probable cluster members, class 4- to likely nonmembers.

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